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EVALUATING LAND PRICES UNDER ENVIRONMENTAL REGULATION

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Abstract

In this paper we present a novel application of the difference-in-difference method to analyse the effect of regulation on agricultural land prices in the case of implementation of mandatory riparian buffer zones. The buffer zones are adjacent to streams and lakes and are designated as part of the Danish implantation of the EU Water Framework Directive. The buffer zone regulation existed from 2012 to 2015 when the regulation was suspended. Using a hedonic price model we do a difference-and-difference estimation of the development in regional farm land prices for farms with land subject to the buffer zone regulation compared to farms not subject to buffer zones. A number of model specifications are tested but no significant effect on land prices of the buffer zone regulation is identified. This is explained by the fact, that the regulation was based on a subsidy scheme offering flat rate compensation to farmers obliged to establish buffer zones. Thus, results suggest that due to the subsidies, farmers' expectations for the future economic rent are unchanged and, thus, no significant effects on the land prices are identified.

Introduction

Agricultural policy has been a pivotal issue in Europe at least since the foundation of the Treaty of Rome in the late 1950's and hence the early days of the European Union. Price support for agricultural products to give farmers incentives to increase production ensuring self-sufficiency was one of the first policies in the European Community and was the predecessor of Common Agricultural Policy (CAP). One of the objectives of the CAP from the early days to present is income support for farmers. Income support as price support or as decoupled payments is, though, to some degree capitalized into the constraining factor i.e. land.

Generally, all framework conditions for farmers are capitalized into the price of the constraining factor and for several policies - and especially in the case of agriculture - this is land prices. Also environmental policies are capitalized and possibly de-capitalizing land as a production factor if the policy is restricting farm production.

In this paper we analyse the effect on agricultural land prices of the implementation of mandatory riparian buffer zones adjacent to streams and lakes designated as part of the implementation of the EU Water Framework Directive. The buffer zone regulation existed from 2012 to 2015 when it was suspended. As only farms with land designated as buffer zones are affected by the regulation we are able to isolate the effect on land prices. Using a hedonic price model we do a difference-and-difference estimation of the development in regional farm land prices for farms with land subject to the buffer zone regulation compared to farms not subject to buffer zones.

The paper contributes with a novel application of the difference-in-difference method to empirically test the effect on an environmental legislation on the land prices. Difference-in-difference is a quasi-experimental application of the hedonic method (Muehlenbachs, Spiller, and Timmins, 2015). The hedonic method is one of the three methods which have been used to assess the effect of government policies on the land prices (Karlsson and Nilsson, 2014). The hedonic method has been criticized for lack of theoretically derived functional specification (Latruffe and Le Mouël, 2009; Miranowski and Hammes, 1984), but none-the-less this method when applied - has been applied successfully when investigating the price effects on the housing market.

The quasi-experimental part of the difference-in-difference method was applicable in this context because the legislation was concerned with spatially identifiable areas which were used to test whether the price development in the treated areas differed from the price development in surrounding areas. This method is robust to expectation error bias because the implicit assumptions are that the expectations to future price developments are the same in the studied areas as in the control group.

The outline of the paper is as follows. First, we do a review of the theoretical approaches to estimate the impact of economic framework conditions and the land prices. Then we present the principal aspects of the hedonic model and the identification strategy. Then the data are described followed by the results of the estimations and test of different model specifications. Finally, we discuss the findings and present the conclusions.

Framework conditions and the price on land

Basically there are three different approaches to model agricultural land prices where the Present Value Model (PVM) is based on expected future cash flows recognizing also non-agricultural cash flows as well as land appreciations (Burt, 1986; Castle and Hoch, 1982; Engsted, 1998; Featherstone and Baker, 1987; Goodwin and Ortalo-Magné, 1992; Melichar, 1979). Latruffe and Le Mouël (2009) provide a good overview of developments in the present value model approach. The basic problem in this approach is that the revealed output prices are expected prices at the time of investment but evaluated with revealed prices. I.e. it was assumed that the farmers had rational expectations and/or perfect foresight and is thus subject to an expectation error bias (Goodwin et al., 2003).

The second approach is equilibrium models where both supply side and demand side are estimated and the equilibrium price for farmland is reached. Tweeten and Martin (1966) is an early example of this approach using macrolevel data from 1923 through 1963. A more recent approach of this approach is Feichtinger and Salhofer (2016) where they use microdata on plot level to derive their reduced form pricing equation to estimate the capitalization of the subsidy before and after the Fischler-reform starting in 2005.

The third approach is the hedonic type of model (Rosen, 1974) where the characteristics of farm land are attributed with a sales price. Miranowski and Hammes (1984) made an early contribution about the implicit prices of soil quality estimated in Iowa based on few land characteristics. Palmquist (1989) argue for using the hedonic approach in valuing farmland and in Palmquist and Danielson (1989) they estimate the value of erosion control and drainage improvements on the land value. Karlsson and Nilsson (2014) use this method to estimate Swedish land prices, but quite often this model is used to estimate the joint value of land in agricultural use and in non-agricultural use (Borchers, Ifft, and Kuethe, 2014; Guiling, Brorsen, and Doye, 2007; Henderson and Moore, 2005).

As the capital value of agricultural land in most cases is the essential component for determining the price of agricultural land, it seems reasonable to expect that changes in the framework conditions, e.g. changed prices on sales products or policies affecting output or production costs, - which change the expected Ricardian rent should results in changes in future land prices.

The applicability of the difference-in-difference method is dependent on differences in the effect of the environmental regulation on farm land. Something needs to be treatment and something needs to be a control group. In this particular case it was the fraction of farms being influenced by the environmental regulation and a large share of farms in the control group.

Hedonic Theory

The hedonic method is well documented in numerous paper and textbooks, e.g., Palmquist (2005) and Bockstael and McConnell (2007). The hedonic price function is an equilibrium function created by sellers and buyers of properties seeking to maximize their profit and utility. In equilibrium, the sales price of any house is a function of its characteristics. The model is based on the assumption of weak separability, which means that the marginal rate of substitution between any two characteristics is independent of the level of all other characteristics. Thus, the hedonic model can provide an estimate of the implicit price of the marginal change of property characteristic (Palmquist, 1991, 1992). Only a handful of studies have attempted to go beyond implicit price and estimate Rosens (1974) second stage willingness to pay function.

The hedonic price function is an equilibrium function that describes a single market. To estimate a hedonic price function on more than one market will result in biased estimates. Nevertheless, the theory provides almost no guidance to what a market consists of. The closest definition the literature provides is that a "true" market exists if market participants do not consider buying houses outside that particular market (Taylor, 2003).

In this paper we will we will attempt to trace out the meaning of Willingness To Accept (WTA) for the impact of the buffer policy. We will treat the policy implementation as a non-marginal exogenous event in the farm land market which can be handled in quasi-experimental research design in a difference-in-difference model setup (see section identification strategy). This approach ensures a strong identification strategy which reduces the problem of unobserved characteristics correlated with the riparian buffer zone variables. Previous studies have used the difference-in-difference method to estimate the capitalized effect of exogenous event in the housing market (Gibbons, 2015).

Identification strategy

We use the difference-in-differences method to identify and isolate the effect of the buffer zone policy on farms. We do this by exploiting the variation across time and treatment between different farms. The idea is to systematically compare farms with and without streams and lakes before and after the implementation of the buffer zone policy. If the buffer zone policy affects the farms negatively, we will find a price effect among farm properties that have lakes and stream and which are sold after the policy implementation.

The difference-in-difference specification we apply in this paper can be written as follows:

$$ln(P_i) = \beta_0 + \beta_1 B_i + \beta_2 T_i + \beta_3 B_i * T_i + \beta_x X_i + \delta + \varepsilon_i \qquad (1)$$

Here, P, is the price of the i'th farm properties, β are parameters to be estimated, X is a vector of control variables accounting for numerous other relevant attributes of the farm. The amount of lakes and streams on the property is denoted B, and the introduction of the buffer policy is captured by the dummy variable T. The interaction between $\mathrm{B}_i * \mathrm{T}_i$, captures the properties sold after the policy implementation which has lakes and stream that were buffered. Finally, ε is an i.i.d. error term. The model was estimated using a Generalized Linear Model. To account for potential omitted variables, which are likely to be spatial in nature, we apply a fixed effect, δ, across regional provinces.

Data

The hedonic data in this analysis is uniquely rich in terms of variables and number of sales. The data covers all sold farm properties between 2010 and 2015. The data contain a large number of variables such as information of the size of the property, the age and size of buildings both production building and farm houses. The data also includes information about the number animals and type of animals on the property (not included in the sale price) as well as the overall concentrations of animals in the local areal. The soil quality, the amount of forest, lakes and streams and wetland areas are also accounted for in the dataset.

The data were constructed based on the large Danish property OIS-database (OIS, 2017). The spatial outline of each sold property was merged with the spatial cadaster dataset based on the unique property key variable. The number of animals and soil quality were extracted from the CHR-register and map of soil types (from 2014), respectively. The information about forest, lakes, streams, and wetland was added to the dataset using data from the national GeoDenmark database using GIS.

The data include 7,603 sold farm properties where 3,114 properties are above 10 hectares, and 2,793 properties were cropped only with no registered animals. In total 2,365 traded properties in the dataset were affected by the buffer zone policy equal to roughly 30% of the entire dataset. All the transactions are marked based thus excluding family sales and closed auctions. The survey period from 2010 to 2015 was a relative price stable period relative to the years before where the financial crises adjusted the prices notably.

Table 1 – Descriptive statistics

Description	Unit	Mean	Variation	Min	Max
Property size	hectare	19.05	28.70	0.501	271.1
Sold in 2011	0/1	0.15	0.357	0	1
Sold in 2012	0/1	0.163	0.37	0	1
Sold in 2013	0/1	0.17	0.376	0	1
Sold in 2014	0/1	0.174	0.379	0	1
Sold in 2015	0/1	0.184	0.388	0	1
Nordjylland region	0/1	0.272	0.445	0	1
Sydjylland region	0/1	0.279	0.448	0	1
Østjylland region	0/1	0.202	0.401	0	1
Primary pig farm	0/1	0.032	0.175	0	1
Primary cattle farm	0/1	0.068	0.252	0	1
Primary other animals	0/1	0.026	0.16	0	1
Forest	Hectare	1.506	4.297	0	89.12
Wetland	Hectare	0.459	1.602	0	40.39
Lake	Hectare	0.101	0.547	0	20.82
Good soil quality	Hectare	2.98	11.994	0	220
No building	0/1	0.096	0.294	0	1
Number of cattle	Number	4.5	31.86	0	525.7
Number of pigs	Number	5.55	44.24	0	856.1
Number of other animals	Number	0.56	8.409	0	300
Production building	m^2	1,273	2,444	0	54,387
Farm house	m^2	183.8	140.5	0	1,652

Buffer zone variables

Up until the implementation of the buffer zone policy, there was uncertainty about the actual extent of the buffer zones. We therefore initially looked into several different definitions of buffer zones around water elements like lakes, streams, and wetlands. In table 2 we present a descriptive statistics of variables that we used in the difference-in-difference model. According to the policy, the class of lake and stream were a key determinant for buffer zone requirement. Only lakes and streams classified as being natural were required to implement a buffer zone.

Table 2 – Descriptive statistics of buffer zone variables

Description	Unit	average	Variation	Min	Max
Stream	m/hectare	18.94	29.31	0	332.3
Lakes	m/hectare	7.41	19.74	0	492.9
Streams with buffer zone requirement	m/hectare	8.82	18.07	0	283.6
Lakes with buffer zone requirement	m/hectare	6.29	16.62	0	228.0

Results

The model estimation of the difference-in-difference hedonic model was estimated using three different samples; one with the full dataset, one where properties under 5 hectares were removed and one where properties under 10 hectares were removed. This objective of subsampling the dataset was to discover whether price drivers were different for different sizes of properties.

The models include more than 25 variables which capture part of the variation of the transaction price of the farm properties. The most important price driver was the size of the property. We, therefore, adjust property size to vary over time. The baseline of the model was a property with average or below average soil quality sold in 2010.

The three models explained between 73 to 79 percent of the variation. The variables capture most of the variation in the transaction price. The explanation drops as the sample is reduced which essentially means that we are able to capture the additional variation introduced by the small properties. This, however, does not imply that the full model is better. R-square essentially explains how the model captures more relative variation. By introducing more variation – adding small properties to the sample – and then controlling for it we increase the relative explained variation, but at the same time, we can claim to improve the model estimation.

The model estimate shows that the price drivers of the full model compared with the model that includes properties larger than 10 hectares is different for many variables. Forest reduces the price of the property by around DKK[1] 53,000 per hectare across all three models. Properties with streams and lakes that are buffer zone required have a lower price premium per meter per hectare. However, only the parameter estimates related to lakes are significant. The parameter estimates that capture properties sold after the policy implementation which have buffer zoned required areas are all negative but far from significant.

Table 3 – Model estimation

Model	Unit	Full (1)	Properties >5 ha (2)	Properties >10 ha (3)
Hectare	DKK/ hectare	141,454*** (4,147)	138,103*** (7,824)	134,261*** (8,441)
Hectare, supplement 2011	DKK/hectare	9,673** (4,811)	12,441 (14,866)	17,553 (16,950)
Hectare, supplement 2012	DKK/hectare	10,365** (4,525)	12,603 (10,385)	14,994 (11,496)
Hectare, supplement 2013	DKK/hectare	16,341*** (4,492)	18,135* (9,458)	20,312* (10,526)
Hectare, supplement 2014	DKK/hectare	9,981** (4,549)	12,065 (7,942)	14,120 (8,821)
Hectare, supplement 2011	DKK/hectare	22,763*** (4,471)	27,215*** (9,884)	32,594*** (11,094)
Hectare, supplement for Nordjylland region	DKK/hectare	9,053*** (2,728)	9,064 (7,559)	9,204 (7,577)
Hectare, supplement for Sydjylland region	DKK/hectare	-19,148*** (2,569)	-19,136*** (6,013)	-19,572*** (6,010)
Hectare, supplement for Østjylland region	DKK/hectare	35,129*** (3,126)	35,093*** (11,088)	34,973*** (11,157)
Hectare,	DKK/hectare	-52,690***	-52,266***	-52,156***

[1] One Euro is approximately 7,4 DKK.

supplement for forest		(8,598)	(17,441)	(17,764)
Hectare, supplement for good soil quality	DKK/hectare	46,462***	46,099***	45,603***
		(3,229)	(10,037)	(10,059)
Primary pig production	DKK/AU[1]	-4,053	-3,214	-4,317
		(2,540)	(7,336)	(8,137)
Primary cattle production	DKK/AU[1]	15,857***	16,412***	17,505***
		(2,398)	(4,216)	(4,345)
Primary other animal production	DKK/AU[1]	27,603***	44,094***	53,564***
		(6,862)	(10,176)	(12,329)
Production building	DKK/m^2	266***	287***	368***
		(19,7)	(54,9)	(62,8)
Animal concentration * production building, Pig production	AU[1]*m^2	4,903***	4,739**	5,115***
		(0,499)	(1,874)	(1,966)
Animal concentration * production building, cattle production	AU[1]*m^2	-1,2477***	-1,3505**	-2***
		(0,379)	(0,572)	(1)
Animal concentration * production building, other animal	AU[1]*m^2	-2,84***	-6,59***	-9,16***
		(0,65)	(0,90)	(1,83)
Animal concentration * production building, Pig production	(AU[1]*m^2)^2	-0,0000004***	-0,0000004**	-0,0000004***
		(0,00000004)	(0,0000002)	(0,0000002)
Animal concentration * production building, cattle production	(AU[1]*m^2)^2	0,0000001***	0,0000001***	0,0000001***
		(0,00000002)	(0,00000003)	(0,00000003)
Animal concentration * production building, other animal	(AU[1]*m^2)^2	0,0000001**	0,000001***	0,000001***
		(0,00000005)	(0,0000001)	(0,0000003)
Farmhouse size	DKK/m^2	2,570***	4,093***	4,681***
		(595)	(647)	(1,168)
Farmhouse size	DKK/m^2^2	-1,90***	-3,20***	-3,46**
		(0,69)	(0,78)	(1,42)
Size supplement for no buildings	DKK/hectare	33,930***	34,153*	45,718*
		(10,191)	(20,033)	(23,791)
No buildings	DKK	480,715***	743,207***	578,345*
		(149,389)	(121,227)	(298,717)
	DKK/m/hectare	125	-1,315	-4,503

Stream (buffer zone required)		(4,024)	(1,565)	(3,108)
Lake (buffer zone required)	DKK/m/hectare	-9,954	-20,812**	-28,795**
		(25,516)	(9,086)	(12,983)
Stream (buffer zone required after policy implementation)	DKK/m/hectare	-13,310	-3,901	-507
		(33,821)	(16,382)	(19,196)
Lake (buffer zone required after policy implementation)	DKK/m/hectare	-491	-1,279	-2,907
		(4,875)	(1,958)	(4,151)
2011	DKK	-158,536	-376,175**	-807,058***
		(139,656)	(158,214)	(299,927)
2012	DKK	-163,199	-309,095***	-487,425**
		(139,562)	(113,998)	(207,876)
2013	DKK	-181,979	-296,447***	-463,935**
		(139,067)	(112,542)	(204,962)
2014	DKK	-162,603	-309,616***	-482,159***
		(138,235)	(90,569)	(165,550)
2015	DKK	-348,512**	-659,231***	-1,096,770***
		(137,185)	(122,338)	(220,816)
Constant	DKK	85,678	-12,861	-90,486
		(129,819)	(108,636)	(199,584)
Observations		7,603	4,776	3,114
McFadden R^2		0.79	0.76	0.73

Note: *p<0,1; **p<0,05; ***p<0,01

1) Animal Units

Discussion and conclusions

The results from the analyses show that although the model explains a significant part of the variations in the land prices, no significant effect of the buffer zones are identified. An explanation could be that farmers do not foresee that the presence of buffer zones located on an agricultural estate affects the expected future economic rent (including compensation). Why this explanation seems to be reasonable will be expanded in the following.

During the preparation of the policies leading to implementation of the buffer zones, the effects on the farmers' economic performance were heavily debated. Following this discussion, it was decided to offer a subsidy to compensate farmers for the economic loss resulting from appointment of buffer zones. The subsidies were graduated between land in rotation and permanent grassland. For land in rotation the subsidy in 2012-prises amounted to DKK 2,100 per hectare per year and for permanent grassland it amounted to DKK 1,200 per hectare per year. The subsidy was based on the average economic rent in 2008-2010 on the two types of land use (NaturErhvervstyrelsen, 2013). Further, the land appointed as buffer zones were also eligible for direct payments under pillar 1 of the EU CAP of DKK 2,864 per hectare per year. The total yearly payment per hectare of buffer zone, thus amounts to the sum of the subsidy and the direct payment, i.e. DKK 4,860 on land formerly in rotation and DKK 4,070 for permanent grassland. This should be compared with the expected short term loss between DKK 1,100 and 5,900 estimated by Jacobsen (2015). Here it should be noted that the long term effect is expected to be lower as farmers are able to adjust semi fixed and fixed costs in the long run.

In this light is seem reasonable to expect that farmers' expected economic loss resulting from having buffer zones on their estate would have been low. This together with the political uncertainty connected with the expectations of the buffer zone regulation being suspended in case of a change in Government adds to the explanation that the nonsignificant effect of buffer zones in the estimations reflects a realistic expectation that buffer zones would not have a long term – or short term – effect on the economic outcome from the agricultural activities.

Even though this case did not give statistically significant results from the application of the difference-in-difference approach, it has the potential for yielding solid information the about effect of regulation on land prices without the expectation of error biases. This, though, requires natural experiments involving a treatment and control group.

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